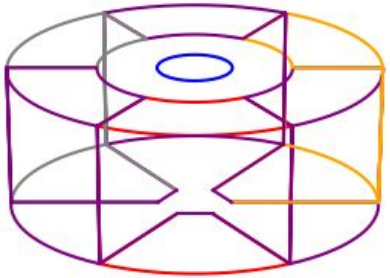
Compton Scanner Measurements on Segmented Germanium Detectors

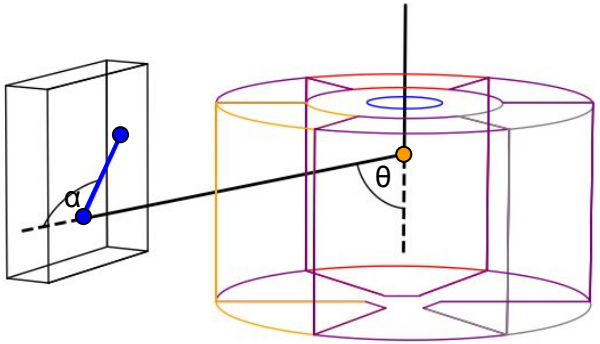
Felix Hagemann

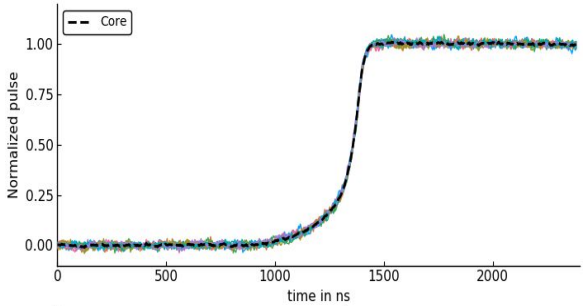
IMPRS recruiting workshop
May 25th, 2020

MAX-PLANCK-INSTITUT
FÜR PHYSIK

Outline







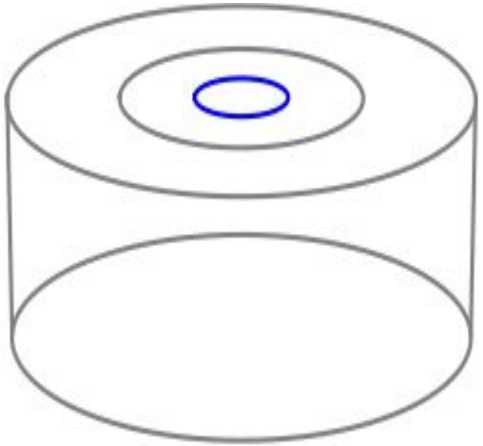
Segmented
Germanium detectors

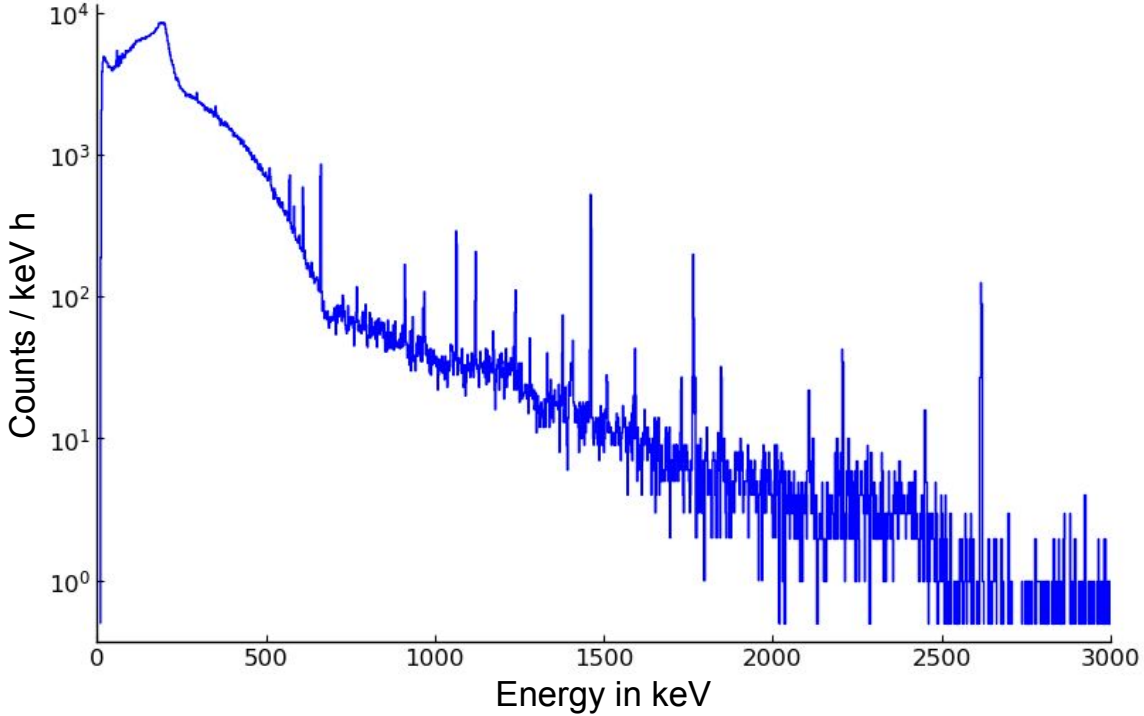
Compton Scanner:
Hardware and software

First results and analysis,
comparison to simulation

MAX-PLANCK-INSTITUT
FÜR PHYSIK

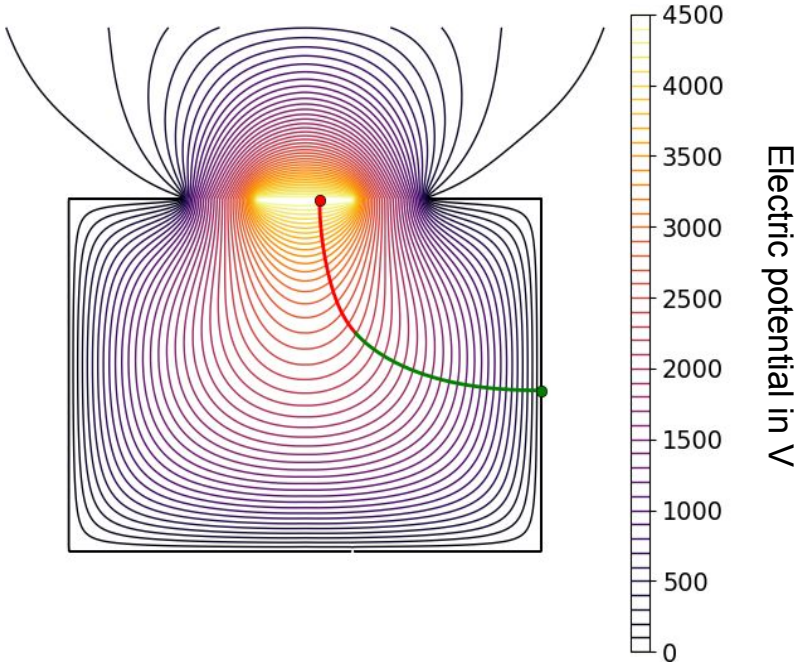
Germanium Detectors

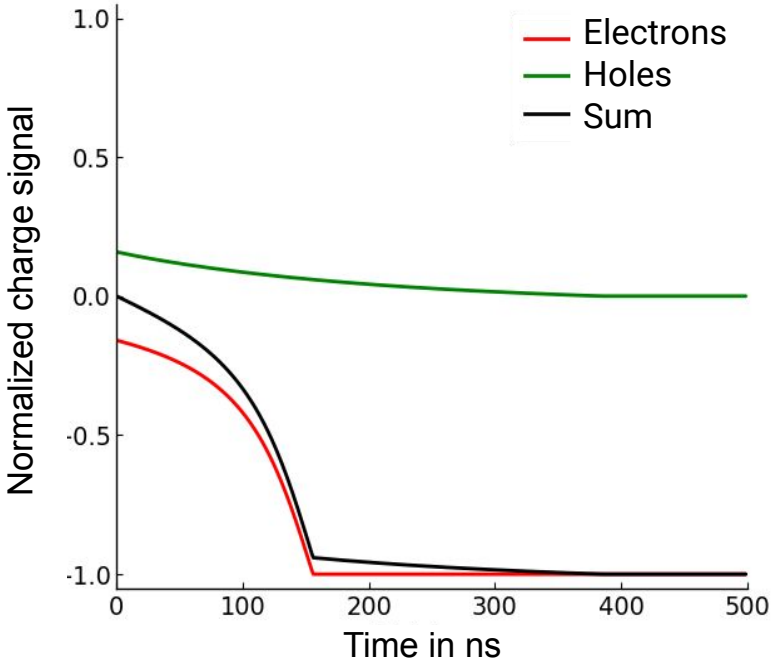




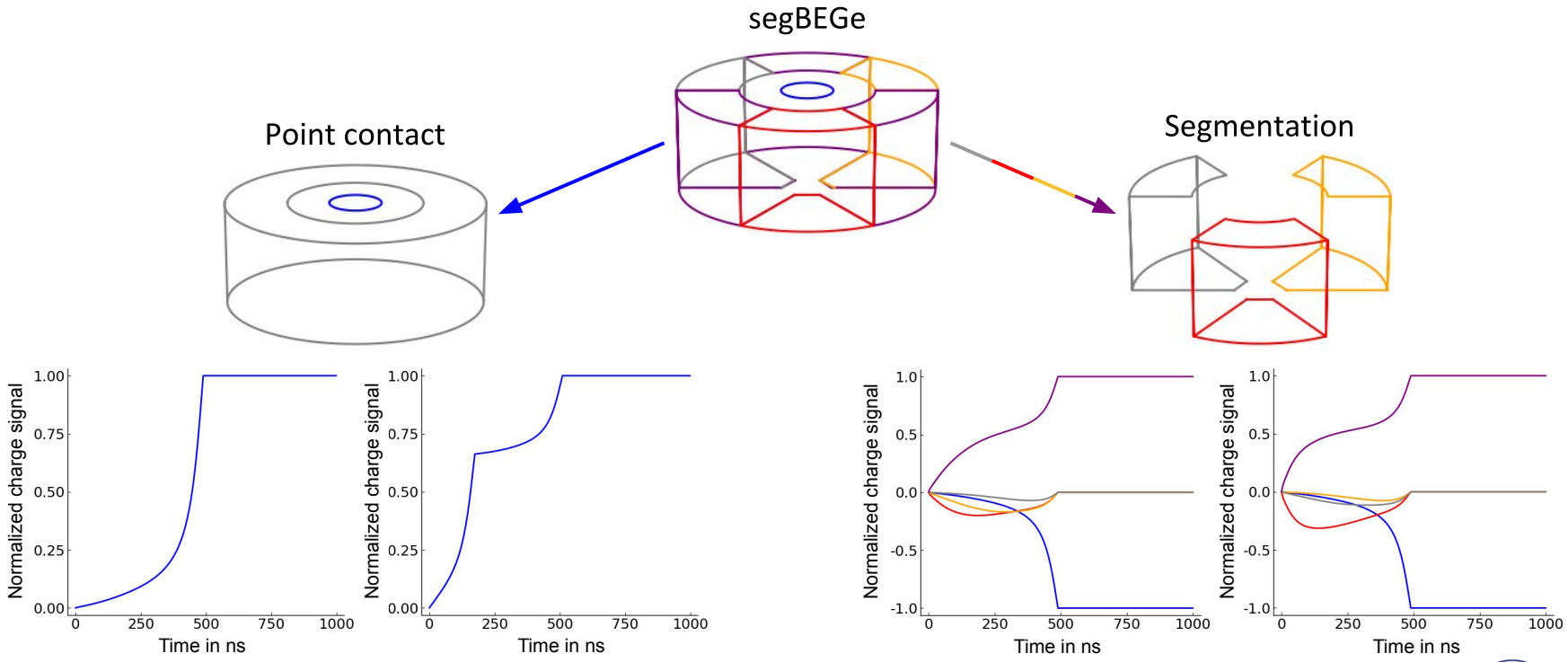
MAX-PLANCK-INSTITUT FÜR PHYSIK

Germanium Detectors



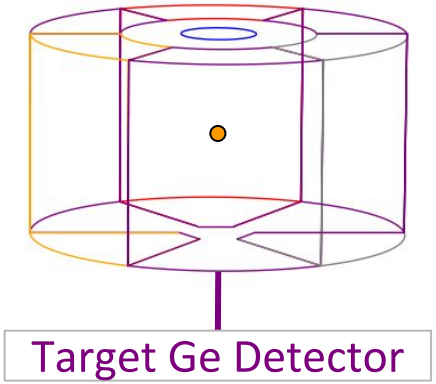


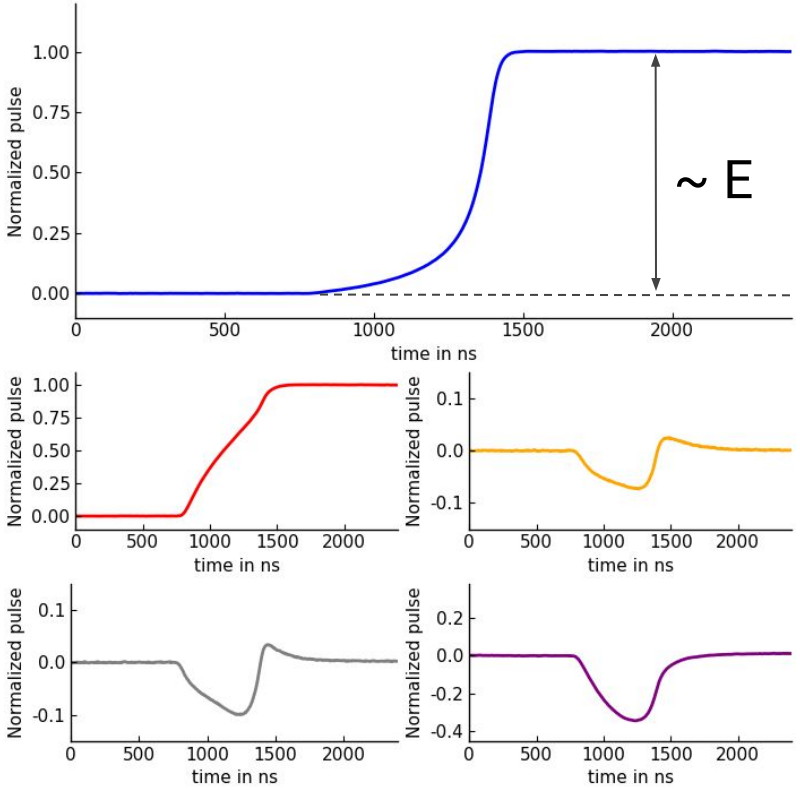
Segmented Broad Energy Germanium Detector



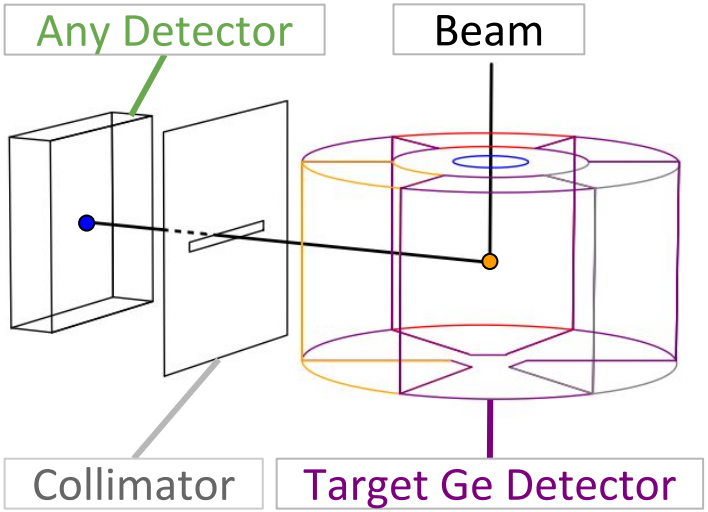
MAX-PLANCK-INSTITUT FÜR PHYSIK

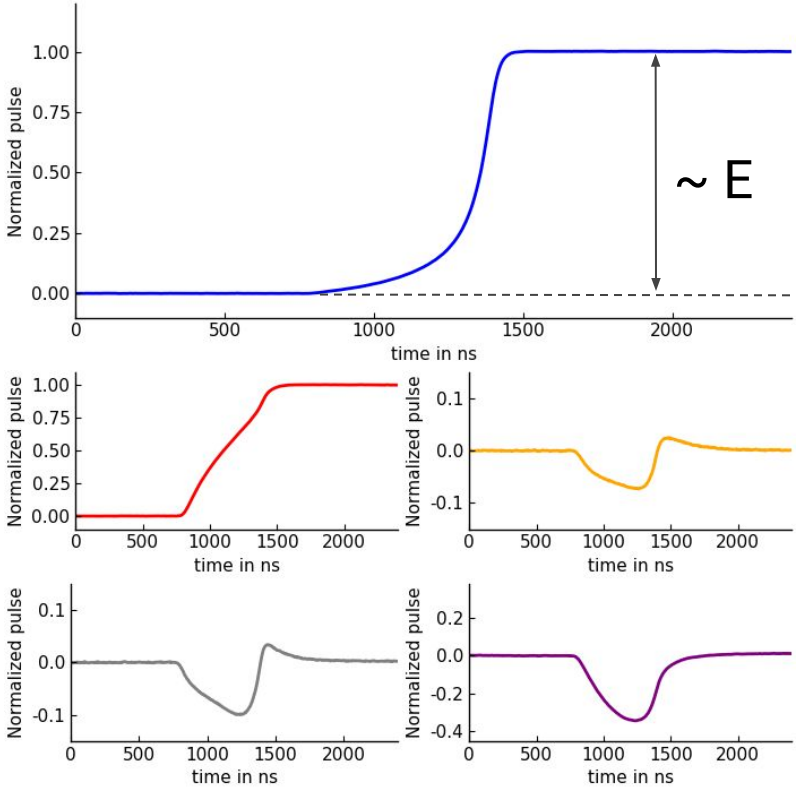
Goal



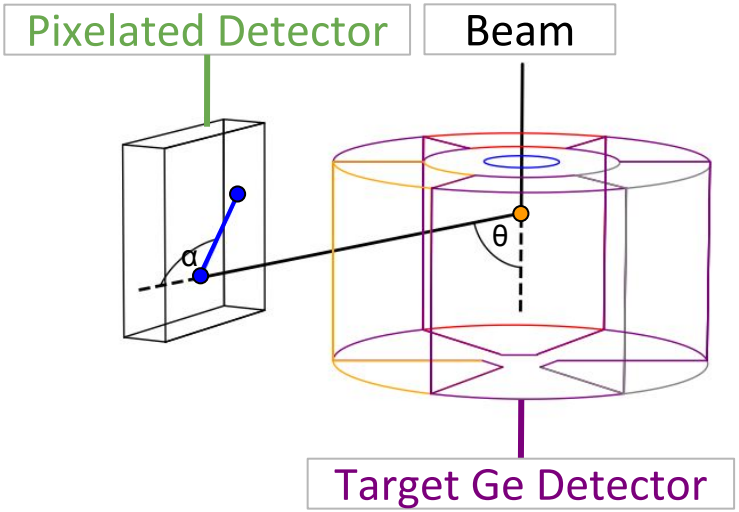


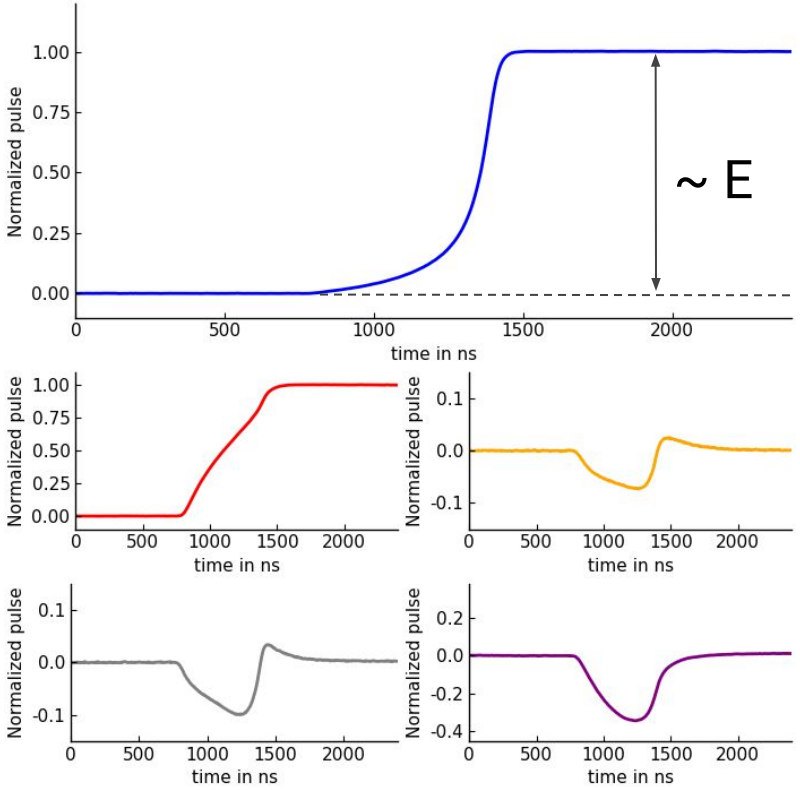
Goal


Any Detector
Beam
Collimator
Target Ge Detector

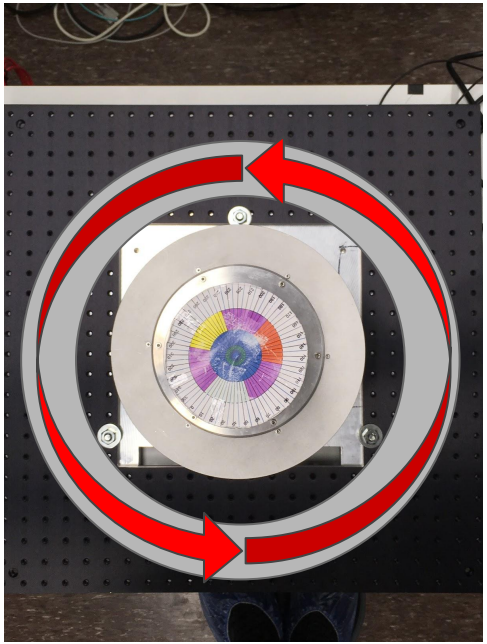

Normalized pulse
time in ns
~ E

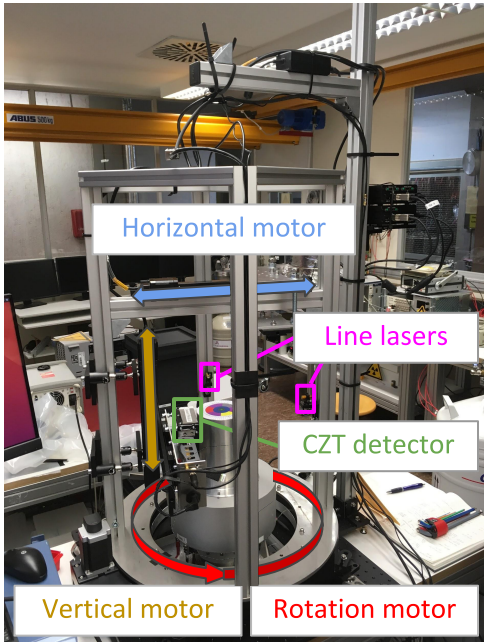
Goal

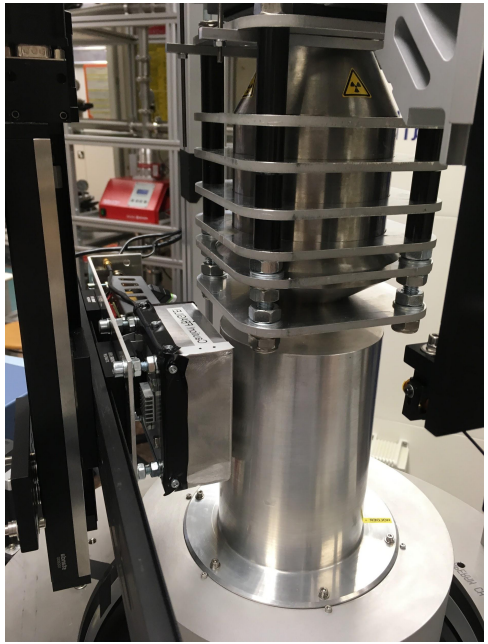

Pixelated Detector
Beam
α
θ
Target Ge Detector


Normalized pulse
time in ns
~ E

Setup and Alignment of Compton Scanner

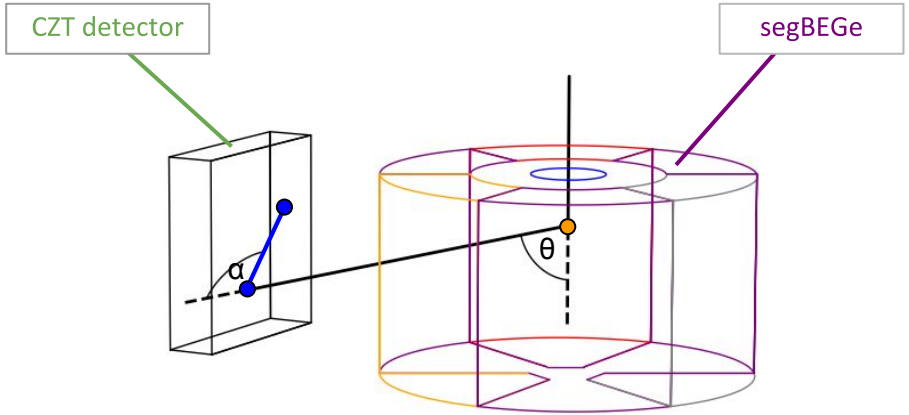


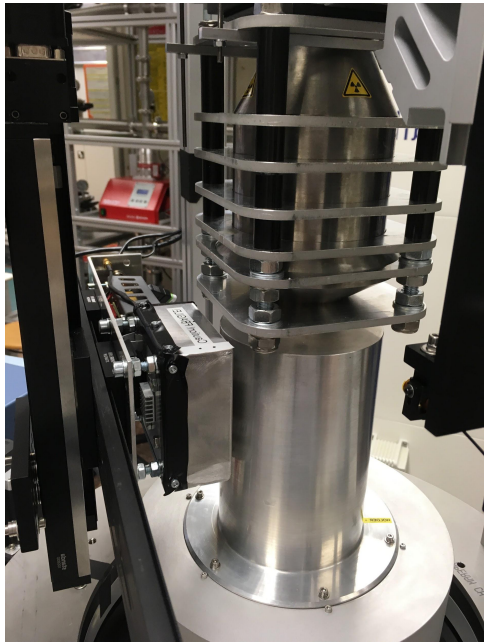




MAX-PLANCK-INSTITUT FÜR PHYSIK

Compton Scanner with segmented BEGe



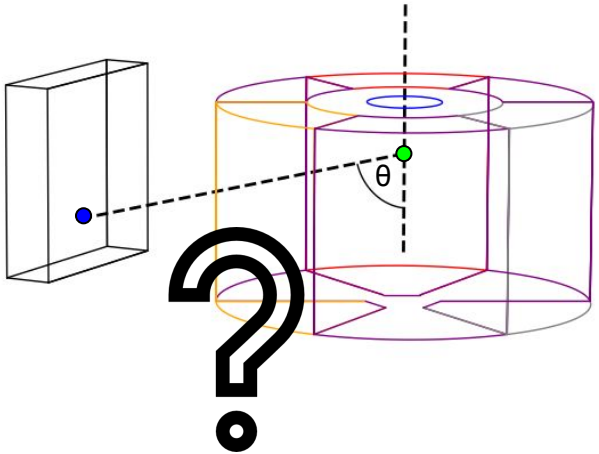


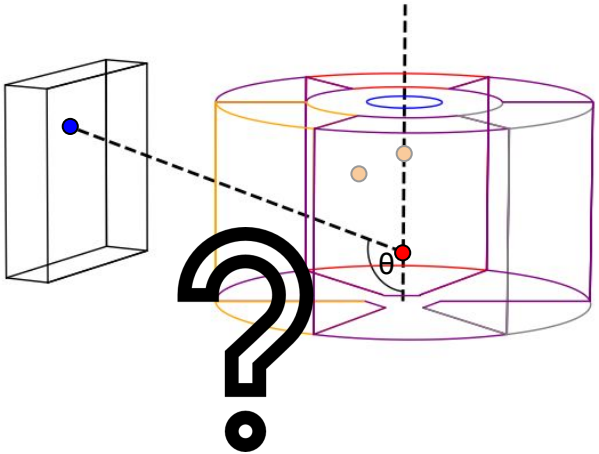
→ time stamp
→ energy deposition
→ position of each hit

→ time stamp
→ energy deposition
→ waveforms

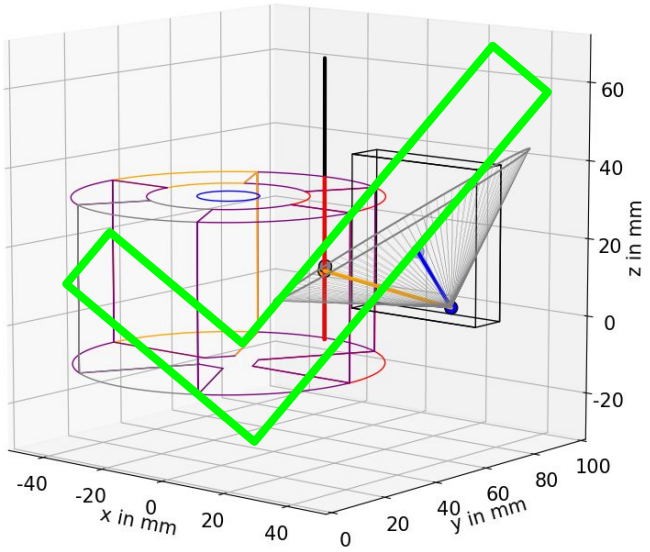
MAX-PLANCK-INSTITUT FÜR PHYSIK

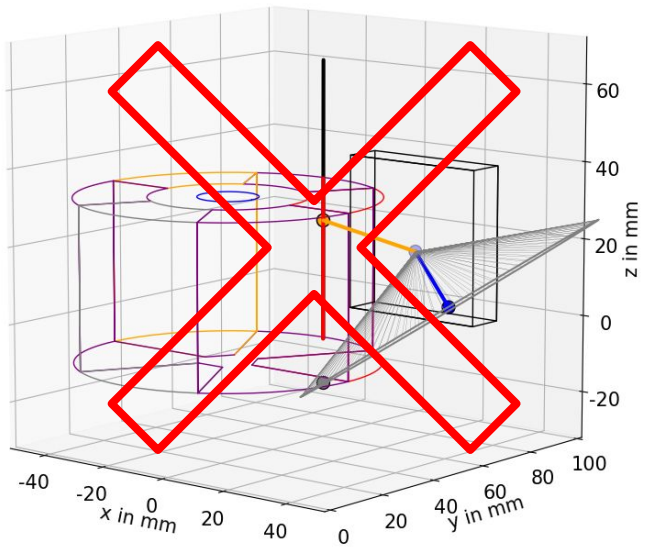
Background for Event Selection





Reconstruction Algorithm





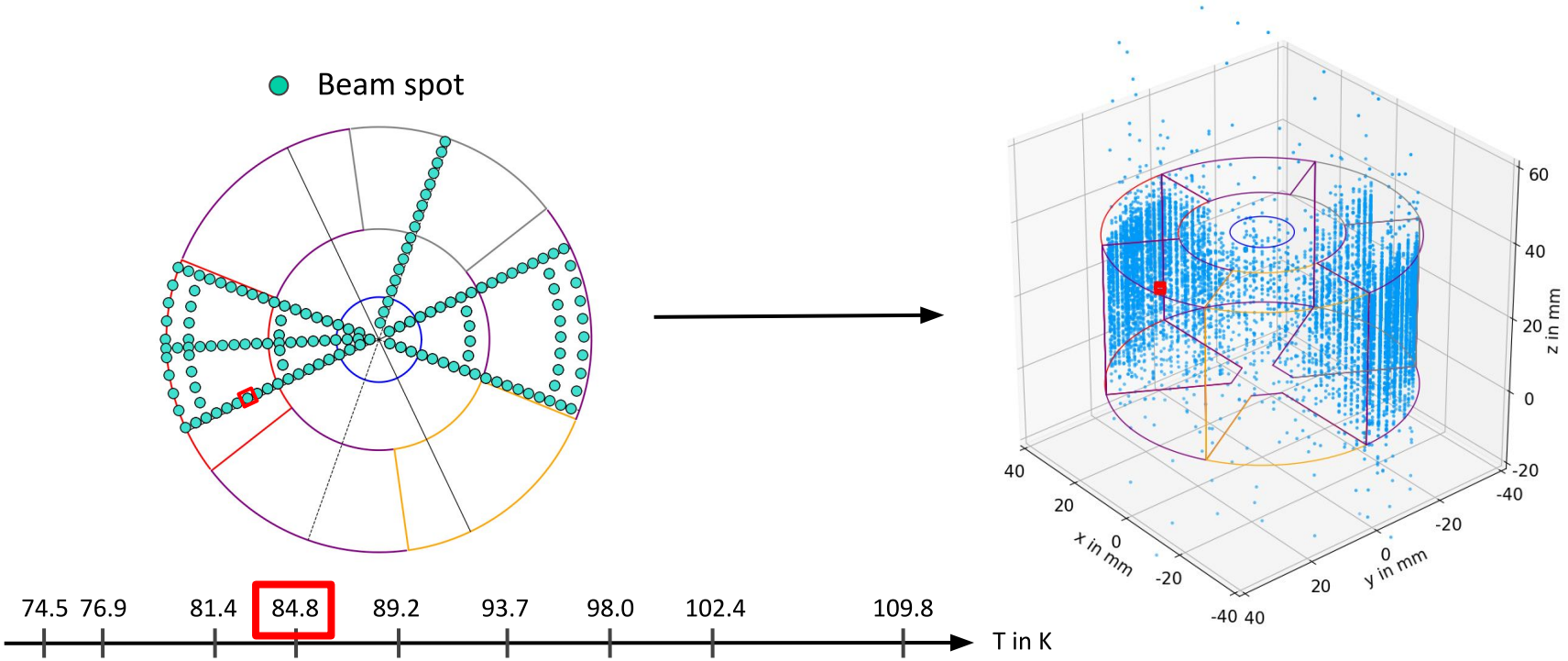
From energy ratio: $\cos(\theta) = 1 - m_e c^2 \left(\frac{1}{E_{\text{out}}} - \frac{1}{E_{\text{in}}} \right)$

$$z_\theta = z + \sqrt{(x-x_0)^2 + (y-y_0)^2}\cot(\theta)$$

From hits in CZT: $$(H_z^2 - \cos^2(\alpha))\, z_\alpha^2 + 2(c_z \cos^2(\alpha) - (\vec{H}_0 \cdot (\vec{c}_1 - \vec{x}_0))\, H_z)\, z_\alpha + (\vec{H}_0 \cdot (\vec{c}_1 - \vec{x}_0))^2 - (\vec{c}_1 - \vec{x}_0)^2 \cos^2(\alpha) = 0$$

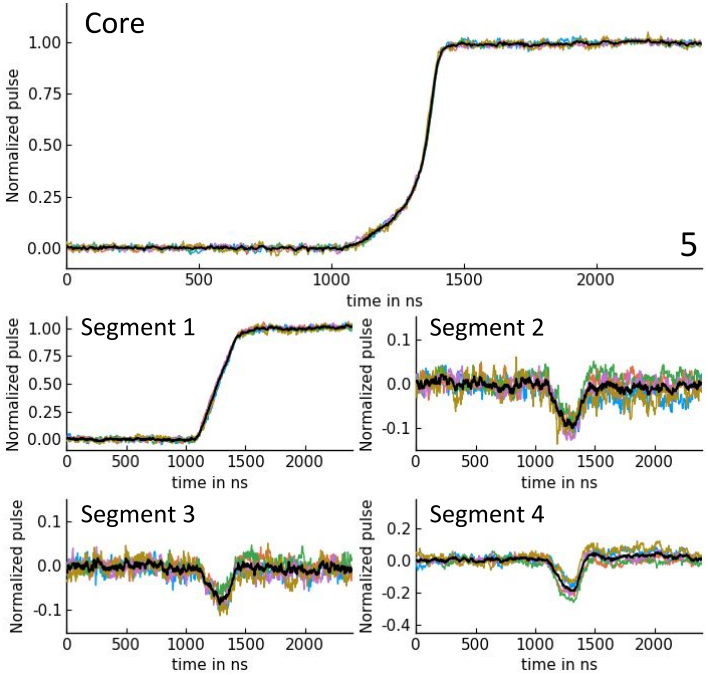
MAX-PLANCK-INSTITUT FÜR PHYSIK

Reconstruction Algorithm Applied to Data

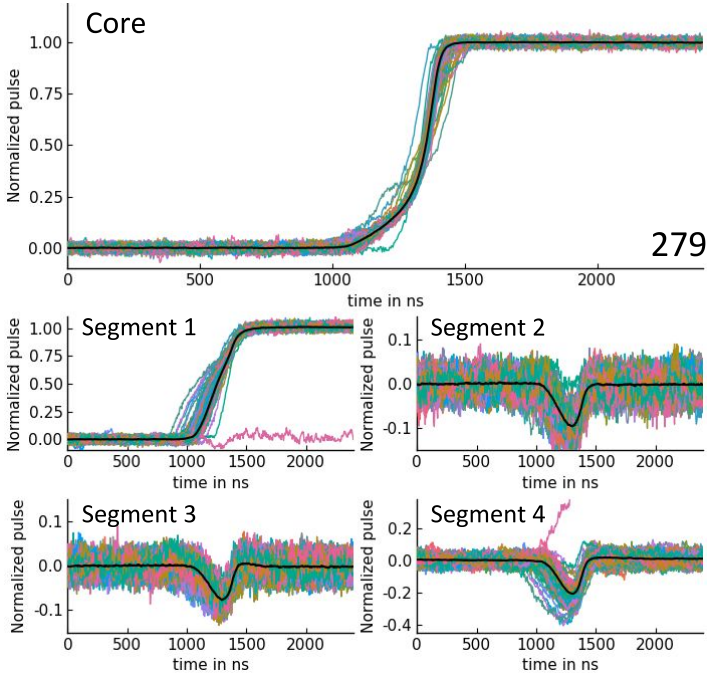


Pulse Shape Selection

From events with **2 hits** in the CZT camera:



From events with **1 hit** in the CZT camera:

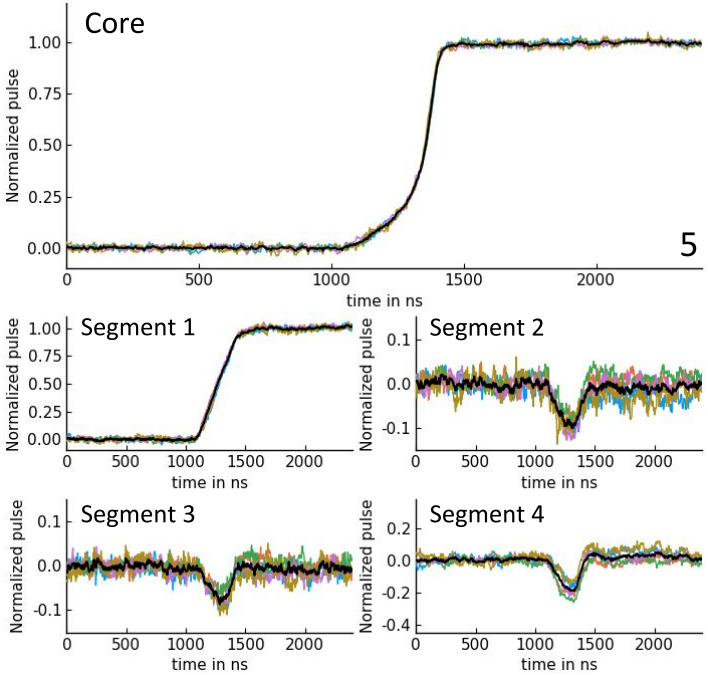


MAX-PLANCK-INSTITUT FÜR PHYSIK

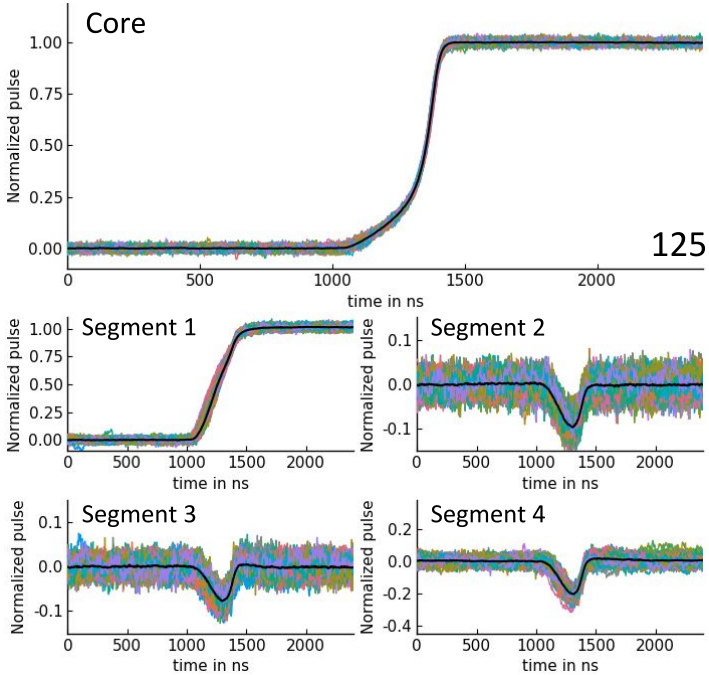
Pulse Shape Selection

→ core similarity

From events with **2 hits** in the CZT camera:



From events with **1 hit** in the CZT camera:

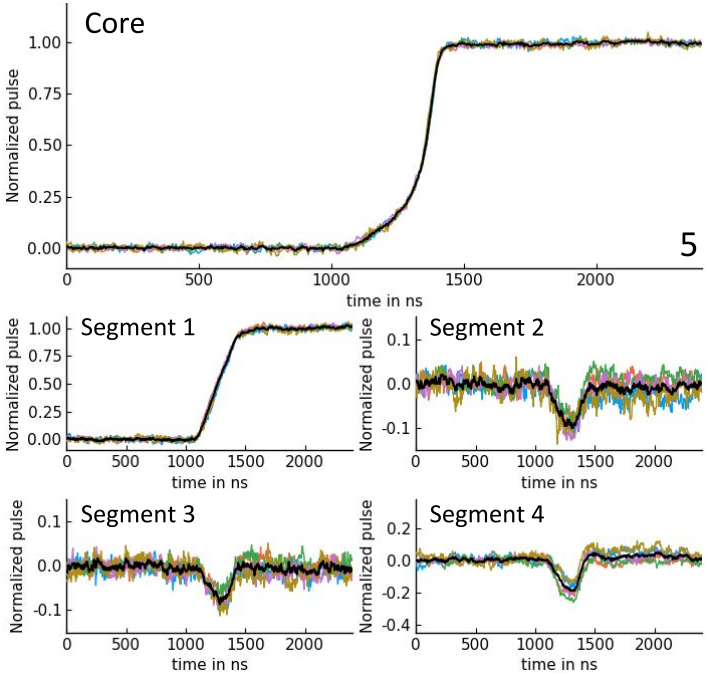


MAX-PLANCK-INSTITUT FÜR PHYSIK

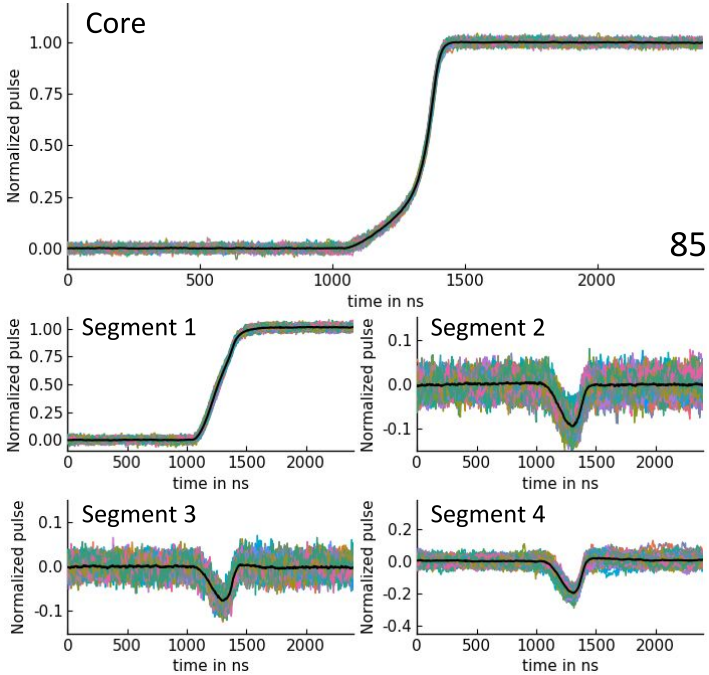
Pulse Shape Selection

→ core similarity
→ collecting segment similarity

From events with **2 hits** in the CZT camera:



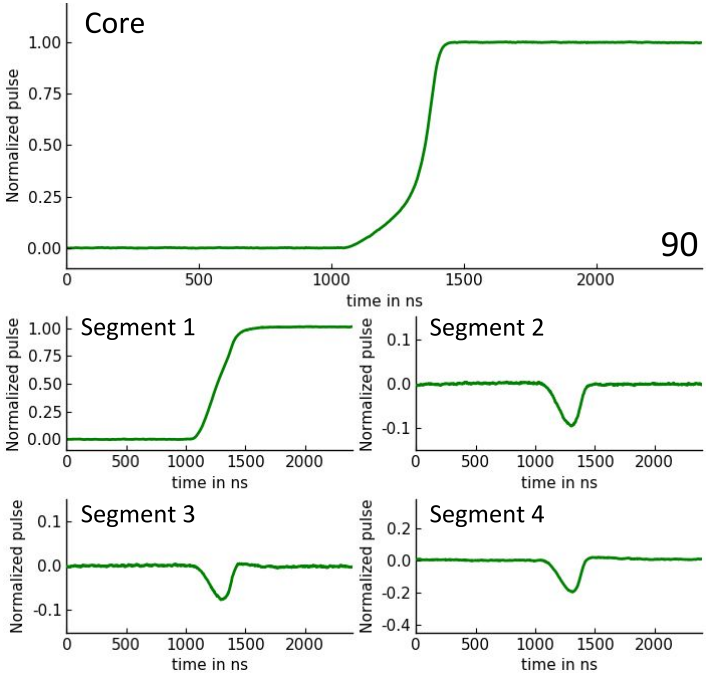
From events with **1 hit** in the CZT camera:



MAX-PLANCK-INSTITUT FÜR PHYSIK

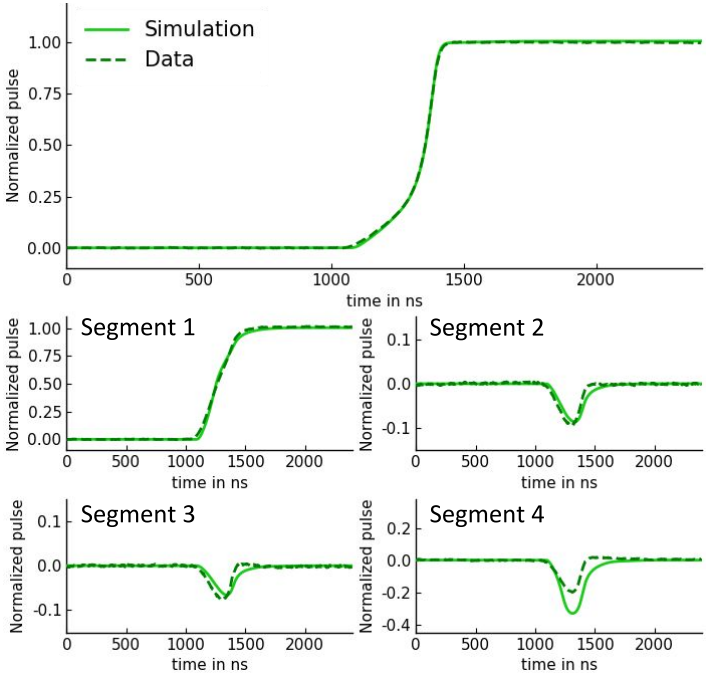
Pulse Shape Selection

Waveforms from data at R = 24.9mm, φ = 25.3°, z = 25mm



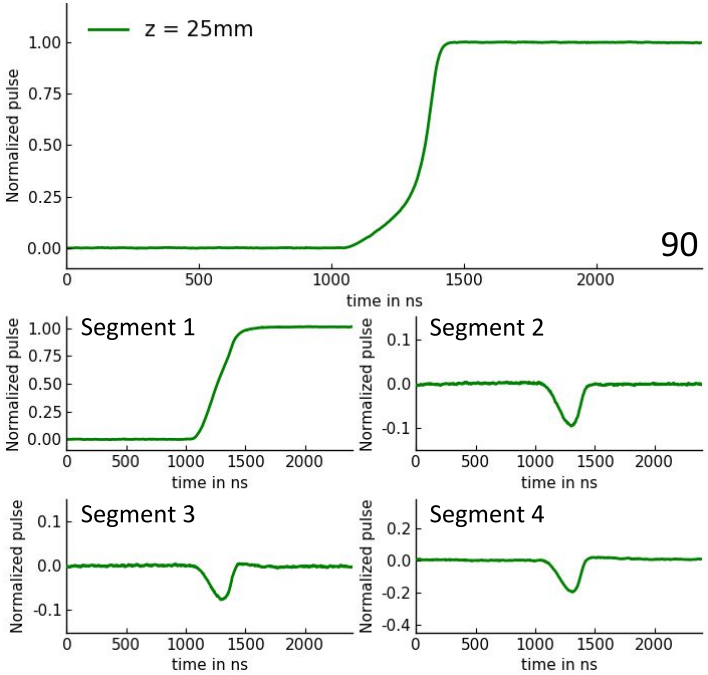
Pulse Shape Comparison to Simulation

Waveforms from data at R = 24.9mm, φ = 25.3°, z = 25mm

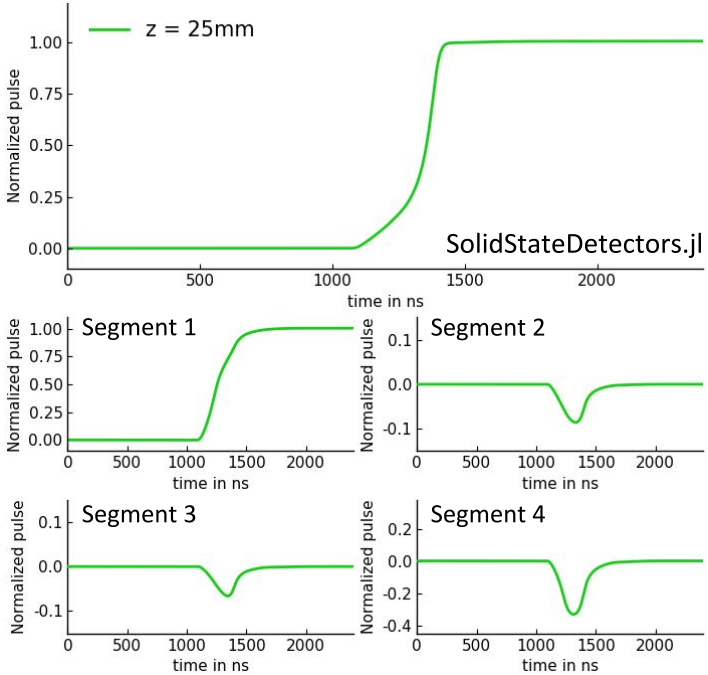


Pulse Shape Comparison to Simulation

Waveforms from data at R = 24.9mm, φ = 25.3°



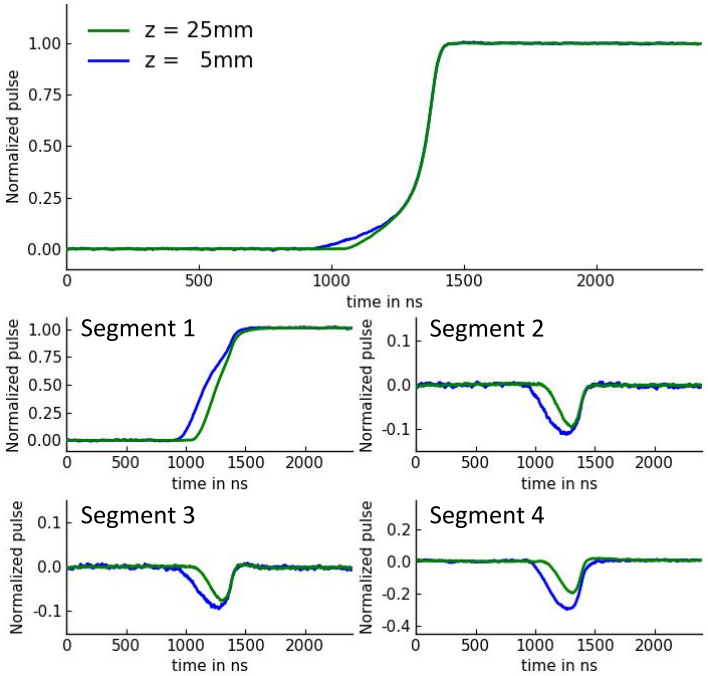
Simulation results at R = 24.9mm, φ = 25.3°



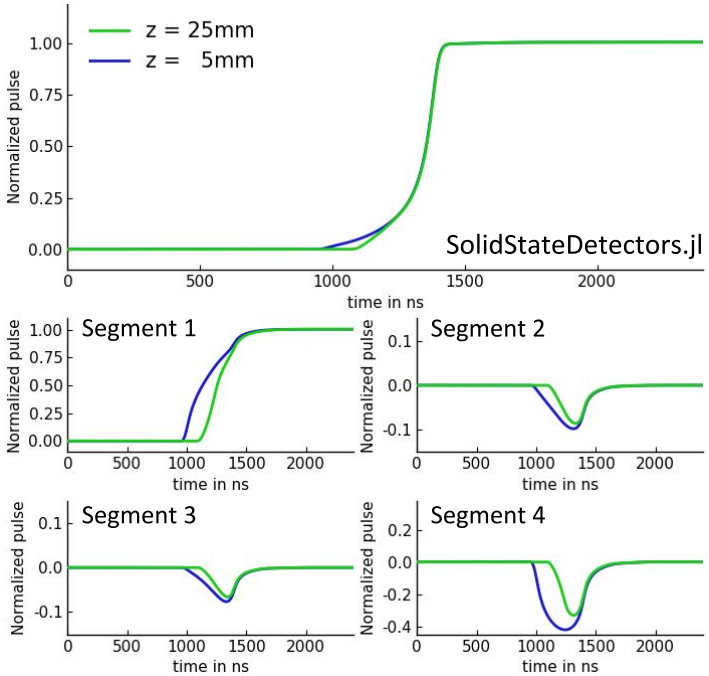
MAX-PLANCK-INSTITUT FÜR PHYSIK

Pulse Shape Comparison to Simulation

Waveforms from data at R = 24.9mm, φ = 25.3°



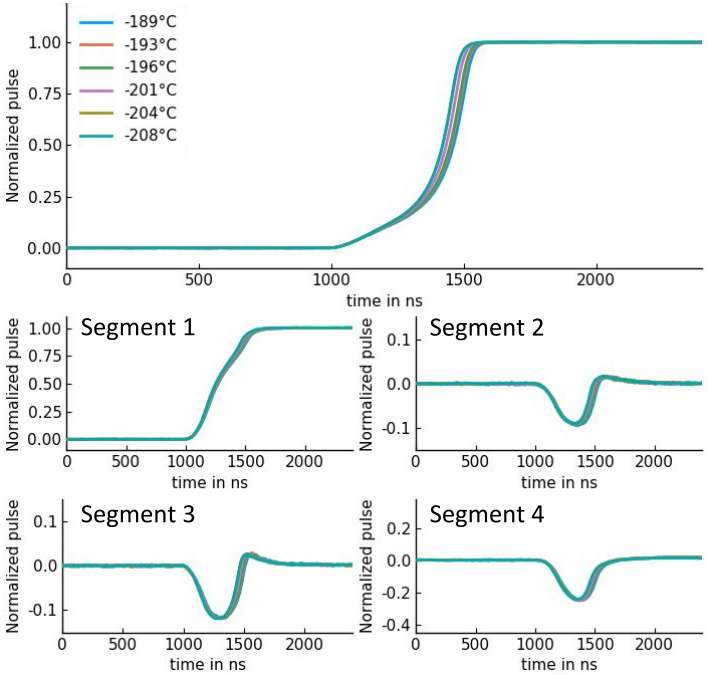
Simulation results at R = 24.9mm, φ = 25.3°



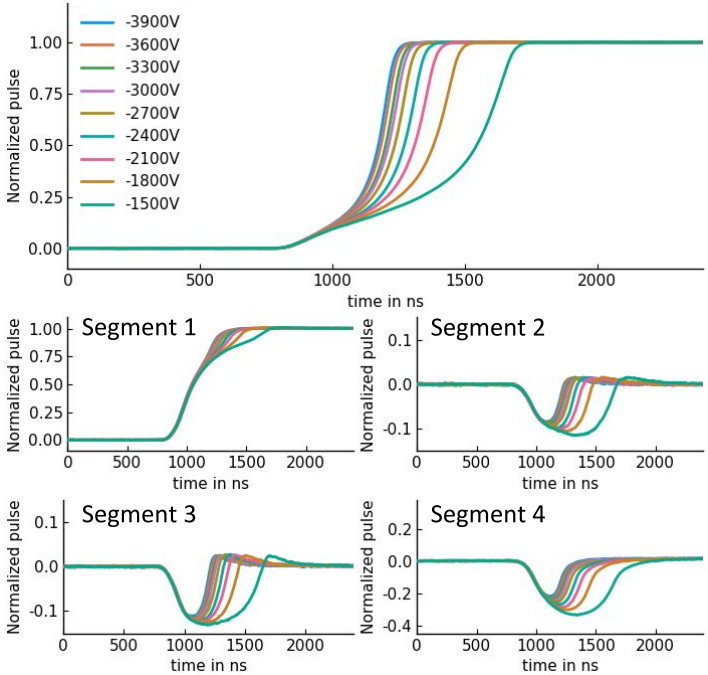
MAX-PLANCK-INSTITUT FÜR PHYSIK

Dependence on Temperature and Bias Voltage

Temperature scan at R = 24.9mm, φ = 25.3°

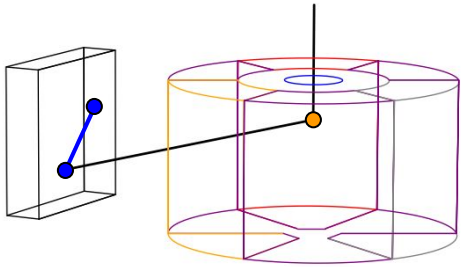


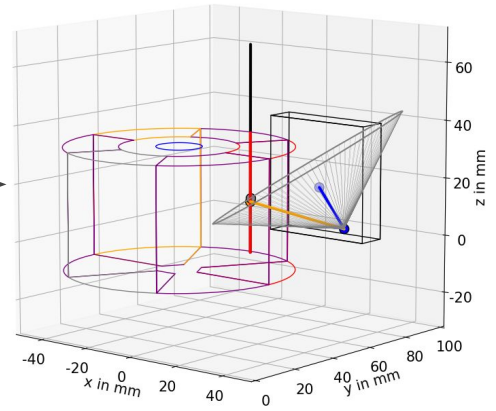
Voltage scan at R = 24.9mm, φ = 25.3°

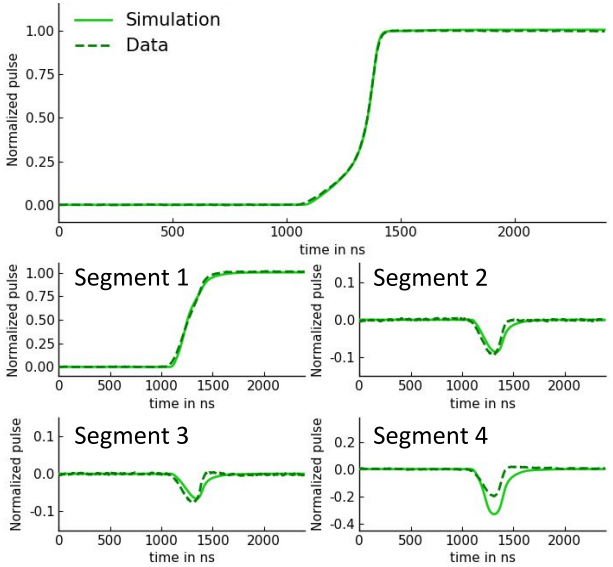


MAX-PLANCK-INSTITUT FÜR PHYSIK

Summary and Outlook







Compton scanner setup with segBEGe successful

reconstruction algorithm written, tested and applied successfully

first results obtained, comparison to simulation very promising